

CONNECTICUT AGRICULTURAL EXPERIMENT STATION NEW HAVEN, CONN.

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The Gypsy Moth.



FIGURE 1.—Female and male gypsy moths. Natural size.

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THE GYPSY MOTH.

Porthetria dispar Linn.

By W. E. BRITTON, *State Entomologist*.

For nearly twenty-five years the State of Massachusetts has been engaged in an attempt to control one of the most destructive insects known—the gypsy moth. In spite of these early efforts the pest kept on spreading and soon reached other states where it has also caused great damage. At the time of this writing, the gypsy moth occurs in all of the New England States, having just been found in two towns in Vermont. The entire area of Rhode Island is infested as is also the eastern end of Connecticut, more than half of Massachusetts in the eastern portion, the southern half of New Hampshire, and the southwestern portion of Maine. Each of these states has appropriated and expended many thousands of dollars in suppressing this insect, and the cost in Massachusetts extends into the millions.

Since 1906, when Congress first made an appropriation for this work, the Bureau of Entomology has co-operated with the states in controlling the gypsy moth.

This insect was discovered in Connecticut at Stonington in 1906, and at Wallingford in 1909—two isolated infestations which have since been exterminated. In the spring of 1913, just after the eggs hatched, the minute caterpillars were carried a long distance probably by a gale and scattered egg-clusters have since been found in eighteen towns in the eastern portion of Connecticut.

Since 1906 the State has expended more than \$31,000.00 in work against the gypsy and brown-tail moths, and during this time the Federal authorities have expended more than \$30,000.00 for labor alone, in moth suppression in the State of Connecticut.

IMPORTANCE OF THE GYPSY MOTH ABROAD.

The gypsy moth occurs in Central and Southern Europe, Northern Africa, and throughout Southern and Central Asia, including Japan and Ceylon. On the European continent the insect becomes abundant at intervals and causes great damage in certain areas.

In general, however, it is held in check by its natural enemies and is nowhere such a serious pest as it has proven to be in this country. It is now considered a rare insect in England. As most of the earlier collections contained plenty of examples of the gypsy moth, while the more recent ones do not, it is fair to assume that it was formerly rather abundant there.

APPEARANCE AND SPREAD IN THE UNITED STATES.

According to the best obtainable information, the gypsy moth was first brought into this country in 1869, or thereabouts, by Mr. L. Trouvelot, an artist and astronomer who was interested in silk culture. In order to overcome a wilt disease or "flacherie" then playing havoc in some silk worm establishments, he tried to cross the silk worm with certain other species to obtain a hardier or more resistant race of silk worms. Among other silk spinning caterpillars in their various stages which he imported from France for this purpose were some egg-masses of the gypsy moth. Some of the caterpillars escaped accidentally from the breeding cages at his home, 27 Myrtle Street, Medford, Mass., and though he searched for them and published a notice at the time, the affair was soon forgotten. The insect was not seen for years, but by 1889 had become a serious pest in this same locality.

The town of Medford first raised a sum of money for its control, and in 1890 the State Legislature made its first appropriation for moth work. At first only a small area was infested, and had the knowledge and experience which we now possess then been available, the pest might perhaps have been exterminated. But methods had to be worked out, men trained, the insect studied, and as many of the earlier methods finally were shown to be ineffective, the insect was not eradicated. Finally after ten years, the Massachusetts legislature in 1900, refused to make further appropriations and the state suppression work ceased. At that time the infested area covered 359 square miles in the vicinity of Boston. For five years no state work was carried on, though many private owners and probably some municipalities controlled the pest on the land under their jurisdiction. In 1905 the gypsy moth had spread and multiplied and become such a nuisance that state control work was resumed and has since been continued; but in 1905, instead of covering 359 square miles, the pest had spread and then covered an area of 2,224 square miles, and extended from beyond

the New Hampshire line south to Buzzard's Bay, and westward as far as Marlborough. A large colony had also become established at Providence, R. I. It had no doubt spread considerably beyond these limits, for it was soon found in New Hampshire and later in Connecticut and in Maine.

In addition to the infested areas mentioned on page 3, isolated infestations have been found as follows: one at Lenox, Stockbridge and Great Barrington, Mass.; Greenfield, Mass.; Springfield, Mass.; Stonington, Conn.; Wallingford, Conn.; Geneva,

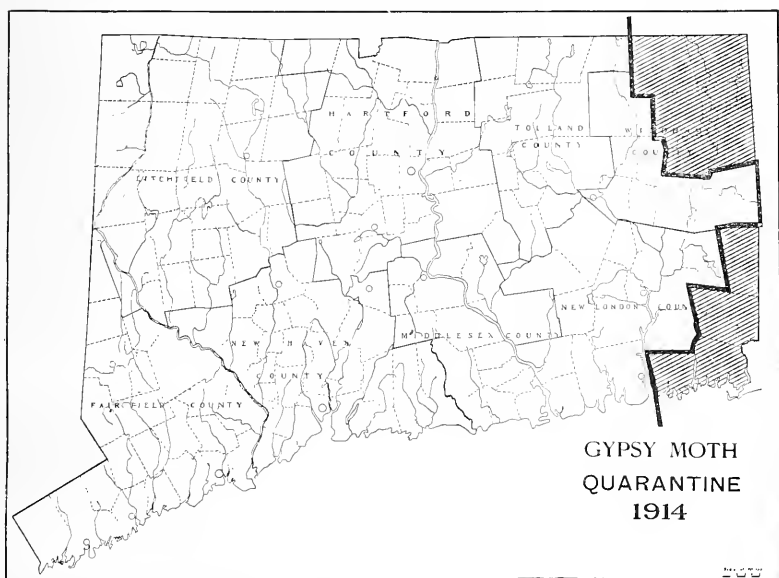


FIG. 2. Map of Connecticut showing area quarantined on account of gypsy moth.

N. Y.; Mount Kisco, N. Y.; Rutherford, N. J.; and near Cleveland, Ohio. The three last named infestations were discovered during the year 1914. These separate infestations have all been, nearly if not quite, exterminated.

DISCOVERY IN CONNECTICUT.

Stonington.

In July 1905, two female moths were taken and two males seen at Stonington by Mr. Ernst Frensch, a collector of insects. Later egg-masses were found. Mr. Frensch communicated with this

office in February 1906, and the writer visited Mr. Frensch, saw his specimens and the egg-clusters. The center of the infestation was apparently in some brush growing around the pond near the velvet mill on the eastern side of the village. These egg-clusters were destroyed and the brush cut and burned. Later other egg-clusters were discovered on apple and other trees in the vicin-

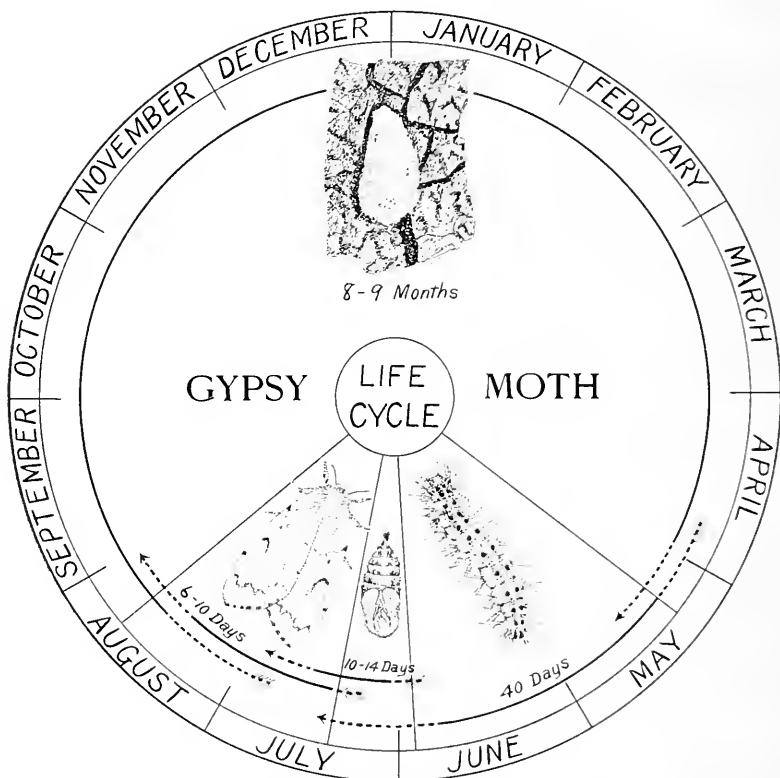


FIGURE 3.—Diagram showing life history of Gypsy moth.

ity and some distance away. Altogether less than a square mile was the greatest area infested at Stonington.

In the summer of 1906 about 10,000 caterpillars were destroyed at Stonington. The number grew smaller each year until 1911 when none were found. It is not known how the gypsy moth reached Stonington, but it may have been brought accidentally from Eastern Massachusetts on some goods shipped to the velvet

mill or its employees, or it may have been brought directly from Europe. The complete records of this infestation are given in the following table:

RECORD OF GYPSY MOTHS DESTROYED AT STONINGTON.

Year	Egg-masses	Caterpillars	Cocoons
1906	73	10,000	47
1907	118	2,936	200
1908	73	2,560	44
1909	6	98	0
1910	1	146	1
1911	3	0	0
1912	0	0	0

Though we believe that this infestation had already been eradicated the work was continued in 1913. Late in the caterpillar season a nearly mature caterpillar was found on one of the banded trees. More men were employed, the entire region searched, and altogether five caterpillars and one pupa were found in Stonington. It seemed to be a reinfestation, and this view was later confirmed by Federal scouts who found the following winter, scattered egg-clusters in nearly all of the eastern border towns of the State. A force of men under the supervision of Mr. Irving W. Davis has been scouting this winter in Stonington and in North Stonington but no egg-clusters have been found.

Wallingford.

The writer's first intimation that a gypsy moth colony existed in Wallingford came on the morning of Tuesday, December 14, 1909, when Mr. B. H. Walden, first assistant entomologist, called attention to an item in the Wallingford News of a New Haven daily paper issued the night before. The paper stated that egg-clusters of this insect had been discovered in the borough, naming some of the streets and stating that the Warden would soon have men destroy the eggs. Mr. Walden at once visited Wallingford and found plenty of evidence of the presence of the pest. Men employed by this office were immediately set at work creosoting the eggs and searching for more.

The presence of the gypsy moth in Wallingford was first noticed by Mr. Leslie A. Brown, a designer of silverware employed by the R. Wallace & Sons Mfg. Co. Mr. Brown noticed an egg-cluster on the trunk of a tree while on his way to his work. He had formerly lived in Newburyport, Mass., where he became

familiar with the gypsy moth and, therefore, recognized the eggs at sight.

Of course, it is not known how the pest was brought to Wallingford, but probably egg-clusters were carried there unnoticed on a crate or packing box. The worst infested section was in the rear of some stores north of Center Street, and these stores receive many shipments of goods from Eastern Massachusetts.

Less than a square mile of territory was infested, the area extending from the railroad east to Fair Street, and from Ward Street northward to Christian Street. More than 8,000 egg-clus-

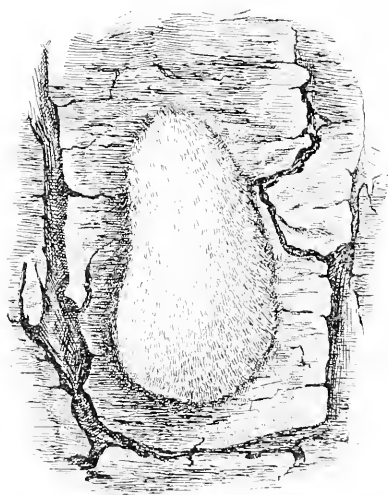


FIGURE 4.—Egg-mass on bark.
Natural size.



FIGURE 5.—Caterpillar. Natural size.

ters were found and destroyed that winter and nearly 9,000 caterpillars the following summer. For three years Mr. Donald J. Caffrey had charge of the work, which was done so carefully and thoroughly that no caterpillars or egg-masses have been found there since. The statistics of the Wallingford infestation are given in the following table:

RECORD OF GYPSY MOTHS DESTROYED AT WALLINGFORD.

Year	Egg-masses	Caterpillars	Cocoons
1910	8,234	8,936	96
1911	23	1,551	15
1912	5	26	1
1913	2	3	0
1914	0	0	0

PRESENT INFESTED AREA.

On account of the limited State funds which were all needed in Stonington and Wallingford, and in the brown-tail moth work, it was fortunate that Connecticut could have the co-operation of the Federal authorities in scouting the eastern end of the State. All of the towns along the eastern border have been searched by Federal scouts, except a portion of the previously infested area in Stonington. At first the Federal scouts examined only the trees in orchards and along the roadsides. They found scattered egg-clusters, one or two in a place, in the towns of Thompson, Woodstock, Putnam, Pomfret, Killingly, Voluntown, North Stonington, Stonington and Groton. Those found in Stonington were in the country north of the area previously infested. Then the men searched the woodland and found many more egg-clusters. Later a search was made in adjoining towns, some of which were found to be infested. At the time of this writing the following eighteen towns may be called infested, though in some of them no caterpillars were found during the summer and no egg-clusters found there this winter:

Windham County.

Thompson
Woodstock
Pomfret
Putnam
Killingly
Eastford
Hampton
Brooklyn
Canterbury
Plainfield
Sterling

New London County.

Voluntown
North Stonington
Stonington
Groton
Sprague
Lisbon
Griswold

FEDERAL QUARANTINE.

The Federal law establishing the Federal Horticultural Board, became operative October 1st, 1912, and authorized the Board to establish and maintain quarantines, of course preceded by due notices, hearings, etc. The first gypsy moth quarantine became effective August 1, 1913, and did not include any towns in Connecticut, for at the time of the hearing in June none of them were known to be infested except Stonington, where the gypsy moth colony was thought to be exterminated, and Wallingford where

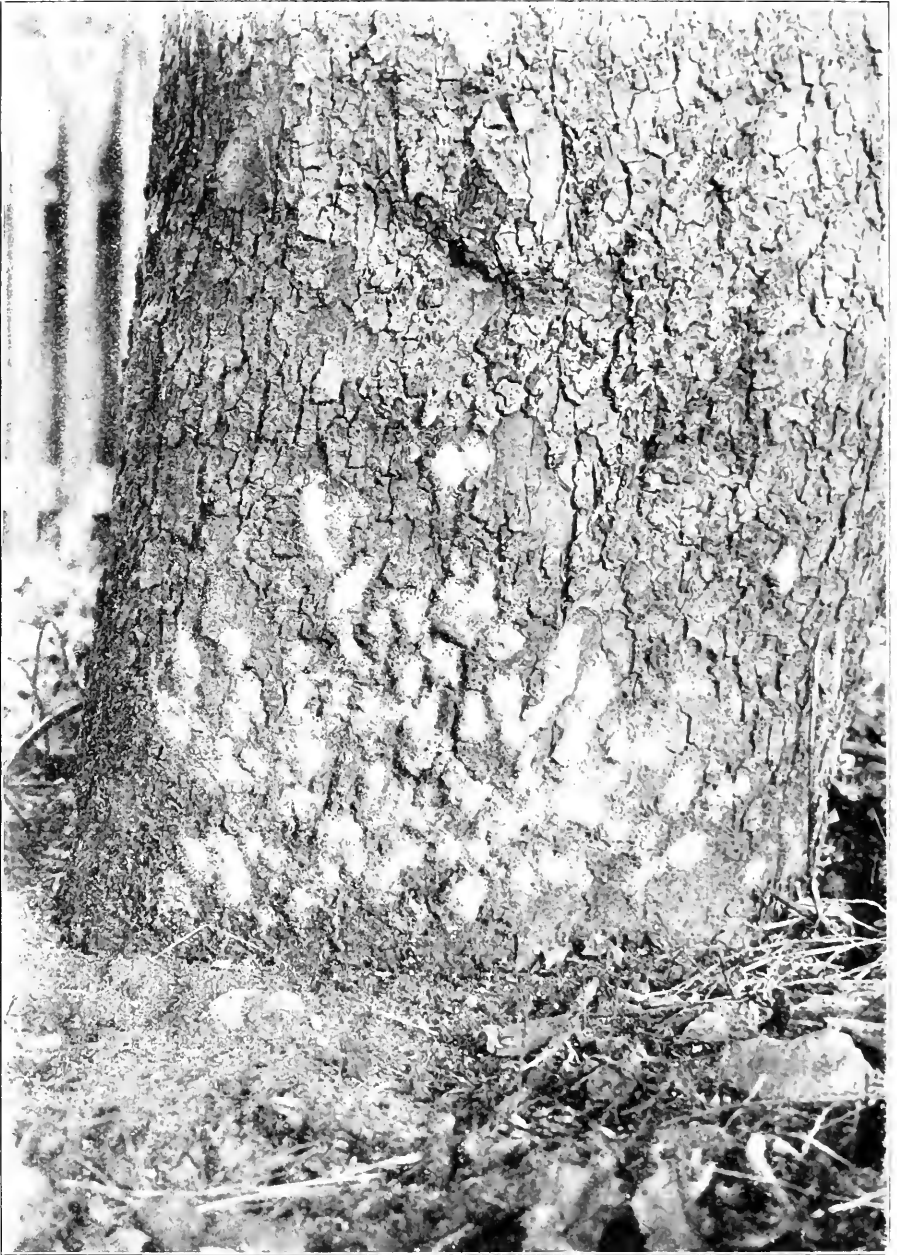


FIGURE 6. Egg-clusters on trunk of apple tree.

only traces of the pest remained. At that time both these colonies were regarded as isolated infestations. A year later, however, the quarantine lines had to be revised, and at present include the following ten Connecticut towns; Thompson, Woodstock, Putnam, Pomfret, Brooklyn, Killingly, Voluntown, North Stonington, Stonington and Groton. Next year the quarantine limits must again be revised to include Eastford, Hampton, Canterbury, Plainfield, Sterling, Griswold, Sprague, Lisbon, and such other towns as are found to be infested prior to the time of the hearing. These towns and the present quarantine limits are shown on the accompanying map figure 2.

All nursery stock, lumber, telephone poles, piles, railroad ties, etc., as well as quarry products, must now be inspected and certified by a Federal inspector before they can be shipped from the quarantined area to points outside this area.

INJURY AND FOOD PLANTS.

The damage caused by the gypsy moth consists in stripping trees, shrubs and other plants of their leaves by the caterpillars. Formerly it was supposed that the caterpillars would attack almost any kind of foliage, ash, being perhaps, the most nearly immune of any of our broad-leaved deciduous trees. In the publication, "The Gypsy Moth" by Forbush and Fernald, is given a list of several hundred food plants, containing nearly all the common cultivated ones. But more recent investigations at the parasite laboratory, Melrose Highlands, Mass., conducted under the direction of Mr. A. F. Burgess, show that the caterpillars in their first and second stages are not able to live on some of these plants even though they may feed on them in later stages of development. For instance, though the caterpillars in their later stages will feed upon pine, and have killed large areas of pine mixed with hard wood in Massachusetts, they must have some deciduous foliage for food in their first and second larval stages. Considering the matter from this standpoint it seems quite possible to cut out all other growth leaving solid stands of pine or other conifers which, with only slight protection, may escape destruction. By the use of tanglefoot on the trunks of the trees around the margins of such an area, little damage will result.

In slight infestations the insects are nearly always found on old apple trees. They are partial to fruit trees, willow, oak, poplar

and rose, but when the caterpillars are abundant, food becomes increasingly scarce and they will feed upon a great many different trees and plants.

METHODS OF SPREAD.

As the insect passes about three-quarters of its life cycle, including the winter, in the egg-stage, there is a long period from late July until the following May, when the egg-clusters may be transported on packing boxes, crates, freight cars, vehicles, nursery stock, lumber, quarry, or other products, which have remained

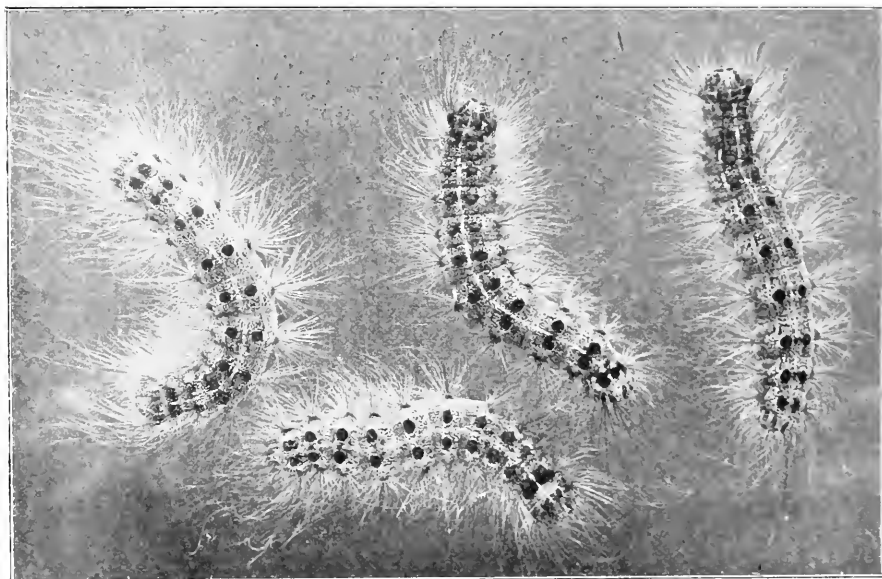


FIGURE 7.—Gypsy moth caterpillars. Natural size.

for a time in July or August in the infested region. This is especially true if these products have been stored, stacked, or allowed to remain where gypsy moths were abundant at the time when the eggs are laid. The egg-clusters are seldom noticed or recognized by the men handling these materials and might be shipped long distances into various states. This is the reason for establishing a quarantine, thus preventing all shipments going out, unless inspected and certified by a Federal inspector. This method of spread will probably account for the isolated infestations at Stonington and Wallingford and most of those in other states.

The caterpillars when nearly grown, and especially if very numerous, crawl about in search of food or a place in which to pupate, and sometimes board trains, trolley cars, automobiles, etc., and may be carried long distances. The insect may also be transported in the pupa and adult stages but as the females do not fly, and as the cocoons are usually in holes or protected places and as such short periods are passed in these stages, there is much less danger of their spreading than in the egg and caterpillar stages.

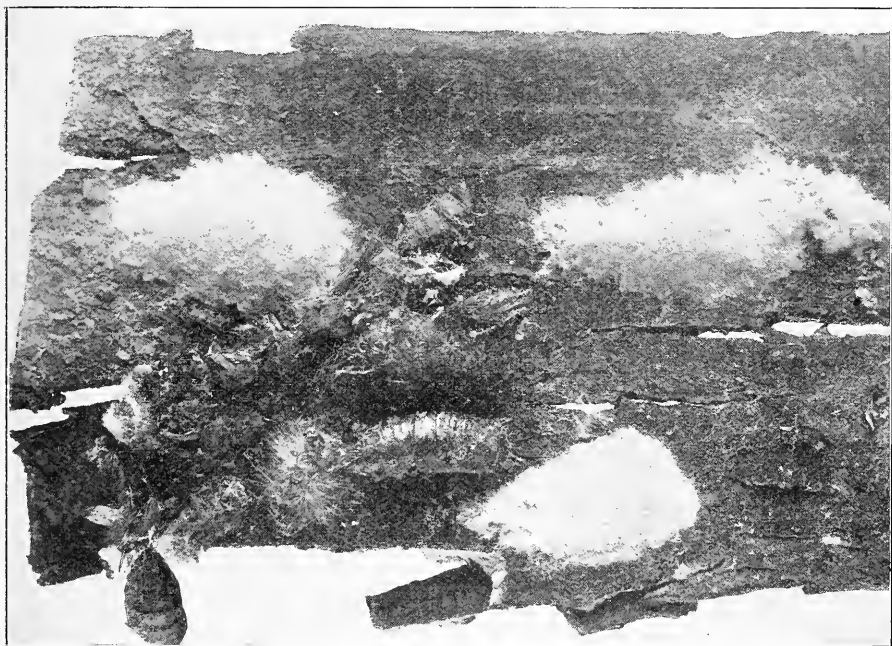


FIGURE 8.—Egg-clusters and pupæ on inside of loose hickory bark.

Wind-spread is probably accountable for most of the extension of the large area of infestation. This extension has been more rapid toward the north and east than in other directions. When the caterpillars first hatch from the eggs, they are of course, very small and are covered with hairs, some of which are bulbous and known as aerostatic hairs. Whether or not this is their real function, it is true that these first-stage caterpillars are carried long distances by strong winds occurring at this time. Mr. Burgess had a large screen placed on the Isles of Shoals, seven miles away

from the nearest infested trees. This screen was covered with tanglefoot and caught several young caterpillars. According to the Federal men, this wind-spread explains the scattered infestations through Eastern Connecticut in the spring of 1913. Of course, if the wind blows toward the center of the infested area no harm will result, but if it blows outward, the area may be greatly increased or extended.

HABITS AND LIFE HISTORY.

The young caterpillars hatching from the eggs about May 1st. feed and hide upon the leaves, spinning down on silken threads

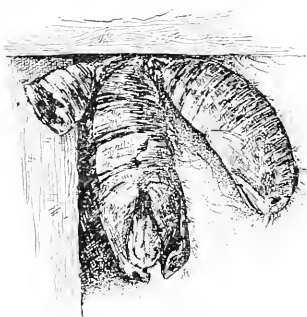


FIGURE 9.—Old pupa skins under fence rail. Natural size.



FIGURE 10.—A Tachinid fly *Tachina mella* reared from a gypsy moth pupa at Wallingford. Three times enlarged.

when disturbed. They usually feed at night and often rest on the underside of the leaves during the day where their presence is apt to be overlooked. They molt five or six times and gradually increase in size, reaching maturity early in July. Caterpillars molting five times usually develop into males, and those molting six times become females, according to Mosher and Webber* who have carried on many experiments and observations at the Gypsy Moth Parasite Laboratory at Melrose Highlands, Mass. During this entire larval period the caterpillars are hairy, dark in general color and some show a predominating tint of brown and others

* *Journal Economic Entomology*, Vol. 7, page 368, 1914.

are gray. There is much variation in size, the largest caterpillars being nearly three inches long (probably molting six times) ; most of them, however, are between two and two and one-half inches. From the time they are half-grown, they hide during the day time in crevices in the bark, in cavities, or in some other dark place, presumably to escape their natural enemies, and are found on the leaves only at night. When fully grown they crawl about to find a protected place in which to make their cocoons. The pupa stage lasts from ten days to two weeks when the adult emerges.

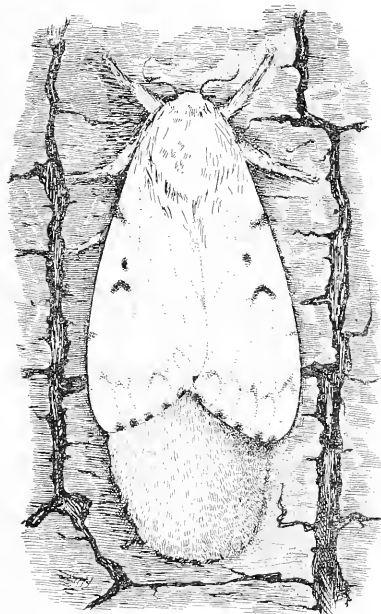


FIGURE 11.—Female laying egg-cluster on bark of tree.
Natural size.

The male moth is generally brown in color and flies about even in the day time. The female is nearly white, with rather inconspicuous cross markings of brown and black, and is larger than the male. The female has a heavy body and does not fly but rests on the trunk or branches of trees, sides of buildings and walls, and in such places she lays her eggs. The adults take no food and live only a short time. It is in the egg-stage that most of the time is spent, the eggs being found about August 1st, until the following May, a period of nine months.

DESCRIPTION.

Egg.—The egg is globular, white or transparent, and slightly more than 1 mm. in diameter. An average of between 400 and 500 eggs are laid together in a cluster and covered with the buff hairs from the body of the moth. The egg-clusters vary greatly in size and shape, but roughly speaking they are oval, about two-thirds as broad as long, and look and feel like a piece of chamois skin. Some large egg-clusters are two inches or more in length, and small ones may be not more than half an inch, but in Connecticut the average length is about an inch. Egg-clusters are shown in figures 4 and 6.

Larva.—The young larvæ resemble the mature ones closely enough so that they may be easily recognized when seen. The



FIGURE 12.—Female moth.
Natural size.



FIGURE 13.—Male moth.
Natural size.

fully-grown caterpillar has a dusky ground color, finely marked with darker spots giving it a granular appearance; sometimes it has a marked brown tint, and sometimes it is decidedly gray. There is a lighter stripe along the back with a row of tubercles on each side of it, two on each segment. From the head the first five pairs of tubercles are blue; the remaining six pairs are brick-red. The colors show more prominently as the larvæ approach maturity. There is usually a lighter lateral stripe between the row of tubercles and the spiracles. The ventral surface, legs and pro-legs are light grayish brown. Head is dark brown marked with yellow. Each segment bears six tubercles arranged in a transverse row, each tubercle bearing a tuft of hairs. The larvæ vary from two to three inches in length and are shown in figures 5 and 7.

Pupa.—The pupa is almost naked but is loosely inclosed by a few strands of silk. It is reddish-brown in color with a few short light brown hairs around the spiracles and across the thoracic and abdominal segments; the apical extremity by which it is fastened also bears a tuft of these hairs. The pupæ usually occur in clusters in protected places, such as under fence rails near the posts, crotches of trees, cavities, etc. This stage is shown in figures 8 and 9.

Adult.—The female is dirty creamy white with rather faint, transverse brown markings, and having a wing-spread varying between two and two and one-half inches. The abdomen is heavy, cylindrical, and covered with buff hairs. The male is smaller and much darker in color; he has a wing-spread of about one and one-half inches, with a small and pointed abdomen. The color is brown varying greatly. Antennæ in both sex are pectinate, narrow and black in the female, broader and light brown in the male. The female is shown in figure 12, the male in figure 13 and both sexes in figure 1.

NATURAL ENEMIES.

Every species of insect has its natural enemies. The gypsy moth has several which are native to this country but none of them are effective in holding it in check. One of the large ground beetles *Calosoma scrutator* Fabr., known as the "searcher" or "caterpillar hunter" was rather common under the burlap bands at Stonington and at Wallingford, and was observed eating the caterpillars. One of these beetles in captivity devoured 137 gypsy caterpillars in thirteen days, an average of more than ten per day. *Calosoma calidum* and *C. frigidum* also feed upon the caterpillars, and no doubt other large ground beetles eat them also.

Several species of Dipterous parasites have been bred from gypsy caterpillars. In 1910, a caterpillar was observed at Wallingford with Tachinid eggs on its back. This caterpillar pupated in captivity and from the pupa, emerged a large two-winged fly *Tachina mella* Walk. (See figure 10). The gypsy moth pupa was closely packed with the puparia of the fly but only one adult emerged. Several other Tachinid flies have been reared from the gypsy moth. Several Hymenopterous or four-winged parasitic flies have been recorded as attacking the gypsy moth. Three or four species of predaceous bugs called "soldier bugs" are known to attack and kill the caterpillars.

Though upwards of forty species of birds have been observed feeding upon the gypsy moth in its different stages, only a few species are useful in destroying the pest. Among these are the cuckoos, oriole, robin, catbird, blue jay, crow, chipping sparrow, chickadee and vireos.

A wilt disease which has been known for several years and which may be indigenous to this country, kills many caterpillars, and especially during the past two years, has shown promise.

As has been stated, all the natural enemies occurring in New England have so far demonstrated their inability to control or to appreciably check the gypsy moth.

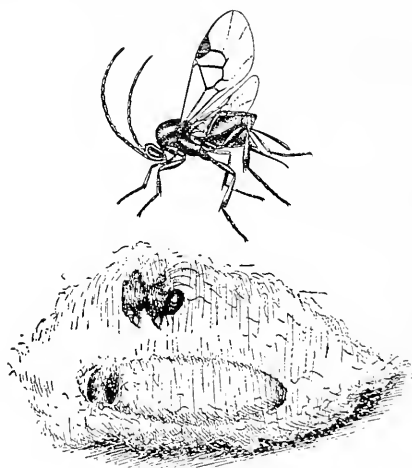


FIGURE 14.—*Apanteles lacteicolor*, a promising imported parasite which has been brought into Connecticut. (After Howard and Fiske, Bureau of Entomology, U. S. Dept. of Agriculture.)

IMPORTED PARASITES.

In Europe, however, the gypsy moth has not been such a destructive pest as in this country and is there held in check by its natural enemies. Beginning in 1905, the State of Massachusetts in co-operation with the Federal Bureau of Entomology, sought to import some of these parasites and predaceous insects as an aid in controlling the pest in the United States. Dr. L. O. Howard made several trips to Europe and enlisted the services of all the leading entomologists of those countries where the gypsy moth occurs. Japan was visited for the same purpose. Para-

sitized material was gathered in enormous quantities and sent to the Parasite Laboratory at Melrose Highlands, Mass., where the parasites were reared and studied; many species were found to be hyperparasites and had to be destroyed. The most promising parasites were reared in large numbers and colonies were planted in situations favorable for their development. Several of these have now become established and have successfully passed several winters.

Among the most important of these imported natural enemies is a large purplish ground beetle *Calosoma sycophanta* Linn., from Europe which in both its adult and its larval stages feeds upon the caterpillars and pupæ of the gypsy moth. A Tachinid fly *Compsilura concinnata* Meig., from Europe attacks both gypsy and brown-tail caterpillars. Two egg-parasites, *Anastatus bifasciatus* Fonsc. from Europe and *Schedius kuvanae* How., from Japan promise to become effective gypsy moth destroyers. Perhaps the most important Hymenopterous parasite is *Apanteles lacteicolor* Vier., which attacks the small caterpillars of both the gypsy and the brown-tail moths. (See figure 14.)

Of these parasites, *Compsilura concinnata* has been planted at six points in Connecticut, *Apanteles lacteicolor* in nine separate localities, and *Calosoma* beetles have been liberated at Stonington and at Thompson. *Apanteles lacteicolor* has been recovered from seven localities in the winter nests of the brown-tail moth.

It is hoped and expected that in time these parasites will materially reduce the numbers of the gypsy moth and thus hold it in check; but it should be borne in mind that parasites seldom or never wholly exterminate their hosts. Until such time as the parasites demonstrate their ability to become a controlling factor in the gypsy moth warfare, we must continue our work of scouting and creosoting the egg-clusters, spraying the foliage, and applying tanglefoot bands to the trees.

CONTROL MEASURES.

Creosoting Egg-Clusters.—Egg-clusters can best be seen when the trees are bare, though they occur from August 1st to April 1st; therefore most of the scouting for them is done during the winter months, especially when there is no snow on the ground. The scouts are provided with field glasses, mirrors and bark knives. They must examine each tree from all sides, look into the

cavities, etc., and by aid of the mirrors can examine the under side of fence rails, etc. They also carry creosote for soaking the egg-clusters to prevent hatching. If creosote is painted over the surface lightly there is danger that some of the eggs will escape injury and hatch: the entire cluster should be well soaked. Creosote is a liquid which can be obtained from nearly all hardware and paint stores, usually costing about 35 cents a gallon, but can be purchased for less in larger quantities. By adding to it a small proportion of lampblack, the egg-clusters are blackened so that the

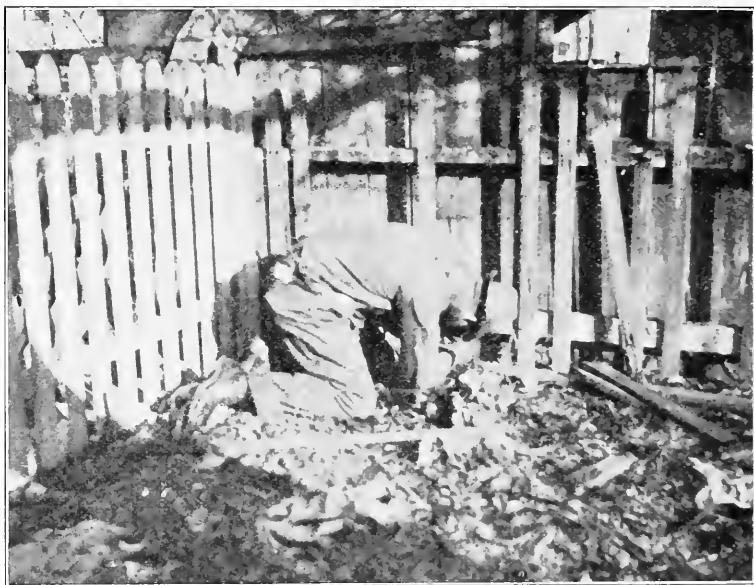


FIGURE 15.—Examining fence and destroying egg-clusters.

treated clusters are easily distinguished from the untreated ones. It is seldom safe to scrape or otherwise remove the egg-clusters from the trees, on account of the danger of breaking them apart. It is always better to creosote them, without scattering them.

Banding Trees.—In former years, applying burlap bands to the trunks of trees as a hiding place for the caterpillars was a common practice, as well one of the important methods of control. In such cases, it was first necessary to remove the dead wood from the tree, fill the cavities with cement or cover them with tin patches, and scrape off the outer or rough bark. In addition to these re-

quirements many old apple trees had to be thinned to let more light into their tops. All of this work was necessary in order to remove all other convenient hiding places for the caterpillars, and to force them to go under the burlap bands. The bands are then turned each day and all caterpillars found under them are destroyed. This method was practiced at Stonington and at Wallingford and is especially adapted to exterminative work in isolated colonies. For this purpose 8-ounce burlap should be cut into strips 8 inches



FIGURE 16.—Method of applying burlap band.

wide, and a band placed around the trunk of the tree at a convenient height tied around the middle with jute wool-twine, and the upper half of the burlap folded down over the lower. This makes a double thickness to shelter the caterpillars. In examining the bands, it is a common practice, to turn them up one day and down the next, thus enabling the foreman to keep a check on the work of his men. On account of the danger of brown-tail rash or poisoning it is advisable not to apply burlap bands until after the middle of June, when most of the brown-tail caterpillars have pupated.

More recently, tanglefoot bands have come into use to prevent caterpillars from crawling up or down a tree. If the tree is suspected of being infested, then it may be sprayed and a tanglefoot band placed around the trunk, thus compelling the caterpillars to feed upon the poisoned foliage or starve. If a tree is free from caterpillars, it may be kept so by the use of the tanglefoot band. Tree tanglefoot is a viscid liquid or paste, which may be purchased by weight in quantities from one pound upwards, the cost varying according to the amount ordered. The tanglefoot material should be applied to form a layer, at least one-fourth of an inch or more in thickness. It hardens after a time, especially in cold stormy weather, and it is necessary to go over it every week or ten days with a comb-like tool to render it effective.

Spraying.—One of the most effective methods of controlling this insect is to thoroughly spray the foliage with lead arsenate paste, using about 5 pounds in 50 gallons of water. Half this weight of dry or powdered lead arsenate can also be used. On orchard or other small trees or shrubs the ordinary orchard hand outfit may be used. Even smaller knapsack or bucket pumps may be used in the home garden. But for spraying a large number of tall shade trees along the street or highway, or in woodland areas, more powerful pumps are more economical. There are now on the market gasoline power outfits with 10-horse power engines that will throw a solid stream into the tops of the tallest trees, the stream then breaking into a spray. Such an outfit, of course, uses more liquid but saves in labor, and enables one to spray the ordinary woodland areas at a cost of six or seven dollars per acre, where formerly the cost was prohibitive often amounting to fifty or seventy-five dollars per acre. For this kind of work the pressure should be above 200 pounds.

SUMMARY.

Distribution.—The gypsy moth occurs in Central and Southern Europe and Asia and Northern Africa, and though it causes great damage in some of the countries, on account of its natural enemies, it is not such a pest there as in the New England States where it has caused millions of dollars damage. It was brought into Massachusetts about 1869 in an attempt to cross it with silk worms to produce a hardy race of the latter. Some individuals escaped from the breeding cages in Medford, Mass., and twenty

years later was such a pest there that the town, and later the State, appropriated funds for its suppression. State work was kept up for ten years, but in 1900 was discontinued. In 1905 it was again resumed, after the pest had spread over more than six times the area formerly infested. In 1906 Congress appropriated money to aid the New England States and the Bureau of Entomology has since co-operated in the control work.

The gypsy moth now covers more than half of the State of Massachusetts (eastern portion), the southwest corner of Maine, nearly half of New Hampshire (the southeastern part), the whole of Rhode Island, eighteen towns in the eastern end of Connecticut, and it has just been discovered in Vermont. Isolated colonies elsewhere have also been found at Lenox, Stockbridge and Great Barrington, Mass.; at Wallingford, Conn.; at Geneva and Mt. Kisco, N. Y.; near Cleveland, Ohio; and at Rutherford, N. J., all of which have been practically eradicated.

The pest was first discovered in Connecticut at Stonington in 1906, where an isolated infestation of less than one square mile in extent was found to exist. Control measures were inaugurated by the Station and continued until the colony was exterminated in 1911.

Another colony was found in Wallingford in December 1909, and similarly eradicated in 1913.

In the spring of 1913, newly hatched caterpillars, were brought into the border towns of Connecticut presumably by a gale from the East. The first caterpillars were found by State employees at Stonington, and in order to learn where they came from, Federal scouts began to examine the surrounding country, and to search the towns along the border. Up to this time eighteen towns, named on page 9 and shown on the map, figure 2, have been found infested.

A Federal quarantine has been established covering the large infested contiguous territory. All nursery, forest and quarry products must be inspected and certified by a Federal inspector before they can be shipped outside of this area.

Food Plants and Damage.—The gypsy caterpillars, when large, feed upon nearly all kinds of vegetation including conifers, which if stripped soon die: newly hatched caterpillars require some other food. Ash is perhaps the most nearly immune of all the deciduous trees.

Methods of Spread.—Gypsy moths are spread as follows:—Egg-clusters are transported in many ways: caterpillars carried on vehicles; newly hatched caterpillars are blown in a strong wind. The former method accounts for most of the isolated colonies, and the latter may explain the increase in the area of long-standing infestations.

Life History.—Egg-clusters laid in summer hatch the following spring, and the caterpillars become fully grown about the first of July. They then go into protected places and transform to the pupa stage. From ten to fourteen days later the adults emerge.

The female is a large-bodied whitish moth, with wing-spread of more than two inches; she cannot fly but lays on tree, fence, wall or building, masses containing 400 or more globular eggs. The male is smaller and darker in color and flies about. The mature caterpillars are between two and three inches long, dark gray or brown, and hairy. A narrow light stripe extends along the back with a row of tubercles on each side. Each tubercle bears light brown hairs. From the head backward the first five pairs of tubercles are blue and the remaining six pairs brick-red. The chrysalis is a naked brown pupa fastened loosely by a few strands of silk.

Natural Enemies.—Native birds such as cuckoos, oriole, robin, vireos, etc., feed upon the caterpillars. There are several predaceous insects, including the large ground beetles and the "soldier bugs" which destroy limited numbers. A few native two-winged and four-winged flies are parasites, but all of these agencies together do not keep the pest in check. All insect enemies of the gypsy moth that can be found throughout its range have been brought from the Old World to New England. Of these, a large ground beetle *Calosoma sycophanta*, a Tachinid fly *Comptosia concinnata* and two four-winged parasitic flies *Apanteles lacticolor* and *Anastatus bifasciatus* have shown great effectiveness, have withstood our climate and multiplied, and have been liberated in the infested territory, including Connecticut.

Control Measures.—The chief control measures are creosoting the egg-clusters, spraying the foliage with lead arsenate, applying tanglefoot bands to the trunks of trees, and thinning the woodland to leave a resistant growth.



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